Issued May 14, 1915.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,

D. W. MAY, Special Agent in Charge,

Mayaguez, P. R.

Bulletin No. 18.

CITRUS FERTILIZATION EXPERIMENTS IN PORTO RICO.

BY

C. F. KINMAN,
Horticulturist.

UNDER THE SUPERVISION OF

OFFICE OF EXPERIMENT STATIONS,

U. S. DEPARTMENT OF AGRICULTURE.

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PORTO RICO AGRICULTURAL EXPERIMENT STATION.

[Under the supervision of A. C. TRUE, Director of the Office of Experiment Stations, United States Department of Agriculture.]

WALTER H. EVANS, *Chief of Division of Insular Stations, Office of Experiment Stations.*

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LETTER OF TRANSMITTAL.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
Mayaguez, P. R., September 10, 1914.

SIR: I have the honor to transmit herewith a manuscript by C. F. Kinman on Citrus Fertilization Experiments in Porto Rico.

During the past 15 years the fruit industry in Porto Rico has grown from an occasional shipment of wild oranges to exports valued at more than $3,000,000 and seems destined in the near future greatly to exceed this amount. Some problems in fruit production have been solved, and others lie before us. The results worked out and methods suggested in this bulletin are of great value to our planters and should be widely disseminated.

I recommend that this manuscript be published as Bulletin 18 of this station.

Respectfully,
D. W. MAY,
Special Agent in Charge.

Dr. A. C. TRUE,
Director Office of Experiment Stations,
U. S. Department of Agriculture, Washington, D. C.

Recommended for publication.
A. C. TRUE, *Director.*

Publication authorized.
D. F. HOUSTON,
Secretary of Agriculture.

CONTENTS.

ILLUSTRATIONS.

CITRUS FERTILIZATION EXPERIMENTS IN PORTO RICO.

INTRODUCTION.

The value of citrus fruit exported from Porto Rico in 1906 was \$295,633, and in 1914, \$1,503,949. During this period, in which not only fruit production but the acreage devoted to oranges and grapefruit has been steadily increasing, fertilization has demanded more attention from the orchardists than any other subject connected with the citrus industry. This is justified by the uniformly favorable results which have followed consistent fertilization and the unsatisfactory returns from groves where little or no fertilizer has been given, and is emphasized by the fact that each grower must solve to a large degree his own orchard problems. The popular opinion in colder climates, from which most Porto Rican citrus growers have come, is that in tropical and subtropical countries, where rain is abundant and the temperature is conducive to a luxuriant growth of vegetation throughout the year, the soil is rich in vegetable matter and has an inexhaustible supply of plant food. The contrary is often the case with soils in Porto Rico. Soil analyses of many of these uplands and rolling areas suitable to citrus culture show them to have very little humus or vegetable matter and but traces of many elements needed in abundance. The moisture and intense heat from the sun hasten the decay of all dead vegetation, and the heavy rains carry away in surface washings much of the decaying vegetable matter, the loamy surface soil, and the dissolved lime and mineral nutrients, leaving after centuries of exposure, in many places, a heavy, red, acid clay. This type of soil needs thorough cultivation, humus, and fertilizers if profitable crops are to be expected.

The constant demands on the soil made by the large population who have done little to retain or build up its fertility indicate a great need for experimental work, the results of which will serve as a basis for fertilization and cultural practices.

SCOPE OF THE EXPERIMENT.

The experiments discussed here were started in 1905 by H. C. Henricksen, at that time horticulturist for the station, in cooperation with orchardists of the island. The latter included the owners

of the Southern Cross plantation, Pueblo Viejo, P. R.; H. C. Leonhardt, Bayamon, P. R.; N. P. Tyler, Manati, P. R.; and the managers of the Cummings' plantation, at Garrochales, P. R.[1] A section of each of these groves was selected, the care of which it was agreed should be under the direction of the horticulturist of the station, and the grove owners supplied the labor needed.[2] Mr. Henricksen continued the work until 1906, when M. J. Iorns was appointed horticulturist. The present horticulturist has had charge of the work since July, 1909.

But for the prompt response to requests for fertilizers, labor, and protection of the experimental plats by those cooperating, the experiment station would have been unable to carry on the work, and credit is due them for any benefit the citrus growers of the island may derive from the results.

Previous to the time these experiments were undertaken, reliable data based on orchard experiments in Porto Rico relating to the chemical and physical needs of soils to be used for citrus orcharding could not be found. Neither were there to be found results of fertilizer experiments conducted in American citrus orchards, where tests had been continued over a term of years and included a sufficient number of combinations of materials to supply comprehensive results or data on which to base experiments here. It was therefore necessary to choose arbitrarily a formula and decide on the quantity and materials to be applied to the various plats. This was done after a careful consideration of the supposed effects of fertilizer on Porto Rican soils and of the apparent needs of the indigenous orange trees.

Many of the complex problems of fertilization were not included in these experiments, but the work was directed to solve if possible a few of the basic questions connected with citrus fertilization. Among these are the effects and possible necessity of adding nitrogen, phosphoric acid, or potash to our orchard soils, and the comparative value of the elements derived from different sources common in the fertilizer trade. While it was impossible in such a cooperative experiment to observe and record in detail all the effects of the fertilizers, the progress of the various plats was noted along lines of primary interest to the orchardist; that is, the general growth and thrift of the tree, the quantity and quality of the fruit produced, and the season of its ripening. Each grove selected for these experiments is situated in an important fruit district of the island and on a soil type representative of the locality. Two of the groves are of grapefruit and two of oranges.

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[1] The experiments at Garrochales were discontinued in 1908.

[2] The station is indebted to the German Kali Works for fertilizers furnished.

PLAN OF THE WORK.

To determine the comparative effects of the three fertilizer constituents—nitrogen, phosphoric acid, and potash—or to prove which is the limiting factor in fruit production on those soils, there was given to each of three plats an incomplete fertilizer, or a mixture containing but two of these elements. Each plat was given one of the three possible combinations. To compare the results from complete and incomplete mixtures and to determine the relative values of nitrate of soda, sulphate of ammonia, and dried blood, and of muriate and sulphate of potash, a number of plats to be given a complete fertilizer were arranged. The tables give in detail the materials applied to the individual plats in each orchard.

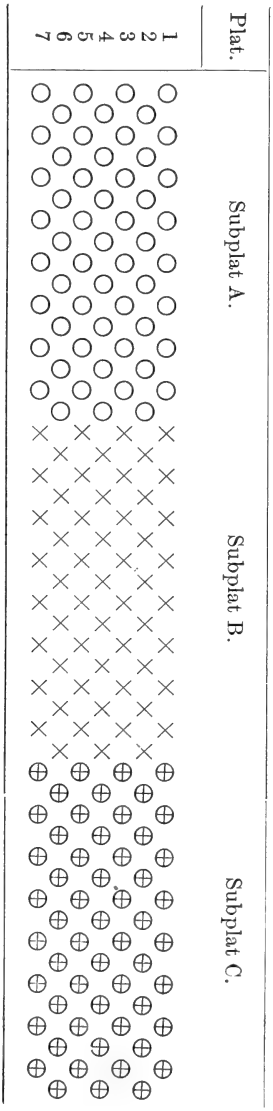

DIAGRAM I.—*Showing location of trees, plats, and subplats in Southern Cross grove.*

In December, 1908, a new formula was decided upon in which the percentage of nitrogen was lowered and the potash increased, though the same materials were used as formerly. At this time divisions were made forming subplats in the original plats because of the marked effects of the fertilizers. Differences in growth and thrift between plats were observed in the different groves. In those at Pueblo Viejo and Bayamon there was found an apparent variation in the flavor of the oranges, supposedly due to the fertilizers used. To make the study of this condition more conclusive, each plat of 24 trees was divided into three subplats of 8 trees each. See Diagram I. Subplats A were to be given the basic formula, while in each of the subplats B and C there was given the same quantity of each element as in subplat A plus an equal quantity of one of the materials.

As there is only a short distance between the plats, and as the subdrainage is poor, the roots make an extensive growth in the upper

soil. Cultivation was given to prevent any root connection between rows, and during the later applications the fertilizer was applied slightly inside the outer branch tips, leaving an unfertilized area between the trees. While the trees were small, however, the fertilized area about each tree extended slightly beyond the branches. After the first two years no fertilizer was given near the tree trunks where the feeding roots are few. As the trees in the different groves were not given the same amount of fertilizer, and as one site was more exposed than another and the soil conditions were not uniform, it is necessary to discuss the results in the experimental fields separately.

Tables I and II show the results of mechanical and chemical analyses of the soils of the different groves.

TABLE I.— *Mechanical analyses of soils from experimental groves.*

Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Southern Cross plantation, Pueblo Viejo:							
Surface soil, upper 9 inches	3.3	17.2	14.3	14.6	5.5	11.9	33.2
Subsoil, 5 to 5½ feet	3.4	23.2	11.7	10.0	3.2	19.6	29.0
Leonhardt's grove, Bayamon:							
Surface soil, upper 9 inches	.4	10.4	13.6	27.8	9.2	14.1	24.6
Subsoil, 5 to 5½ feet	1.7	7.7	10.2	17.7	7.6	16.4	38.6

TABLE II.— *Chemical analyses of soils from experimental orchards.*

Constituents.	Southern Cross grove.		Leonhardt's grove.	
	Soil.[1]	Subsoil.[2]	Soil.[1]	Subsoil.[2]
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Insoluble residue	90.14	78.20	85.29	79.40
Potash (K_2O)	0.04	0.08	0.01	0.08
Lime (CaO)	Trace.	Trace.	.26	.13
Magnesia (MgO)	Trace.	Trace.	Trace.	Trace.
Ferric oxid (Fe_2O_3)	2.02	3.99	5.72	7.86
Alumina (Al_2O_3)	4.12	12.71	2.88	6.68
Phosphorus pentoxid (P_2O_5)	.06	.04	.01	.01
Loss on ignition	3.89	5.79	5.25	6.10
Total	100.27	100.81	99.42	100.26
Nitrogen (N)	.06	.07	.12	.08
Carbon dioxid (CO_2)	.00	.00	.00	.00
Reaction to litmus	(3)	(3)	(3)	(3)

[1] Represents first foot of soil. [2] Represents second foot of soil. [3] Strongly acid.

SOUTHERN CROSS PLANTATION.

The Southern Cross plantation in which experiments were conducted is situated at Pueblo Viejo, one of the sections which first attracted the citrus growers. It is 3 miles southeast of Catano, the

same distance from the sea, and 25 feet above its level. In contour this section is of the gently rolling character, typical of the plateau between the flat coastal plain and low mountains of the interior, where practically all cultivated citrus orchards are located. The immediate site of the experimental plats in the orchard is on land sloping slightly to the west and is characteristic in contour and quality of the orchard lands of this district. The surface soil is a red sandy loam resting on a very heavy sandy clay, and is uniform throughout the plats. There is practically no vegetable matter in the soil except in the upper few inches, where there is enough to give it a grayish color. The red soil below is more firm and is netted with yellowish planes, apparently the planes of cleavage of the rock from which it was formed. The mechanical and chemical analyses give in detail the quality of the soil and the amount of plant food it contains. (See Tables I and II.) This soil does not drain well. While there is always some movement of the soil moisture, there is, during the months of heaviest rains, an excessive quantity of water in the soil for the best development of the trees. When thorough cultivation is given, a sufficient quantity of moisture is retained, even through periods of several weeks without rain. The trees in the experimental plats have never suffered from drought. The local weather conditions are typical of the north central coastal plain. The rainfall and temperature, as estimated by the United States Weather Bureau, are approximately the same as is described for the Bayamon district on page 17.

PLANTING AND CARE OF THE ORCHARD.

The site selected for the orchard was cleared of small trees and shrubs, plowed, and trees from the nursery set in 1903. The trees were placed 25 feet apart in the row, and the rows 12½ feet apart. Therefore, by using an alternate system of planting, the shortest distance between any two trees was 17 feet and 8 inches, which gave 139 trees per acre. None of the trees were lost, but all made a normal and apparently uniform growth.

Except for weeds and grass which were allowed to grow for a few weeks each year during the seasons of heavy rain, the orchard was kept under clean cultivation by the use of plows, disk harrows, and hoes. The first fertilization was given in June, 1906, two and one-half years after the trees had been set. At this time the trees were all making a thrifty top growth, and the tree trunks 6 inches above the crown averaged 8.57 inches in circumference. Table III gives the original plan of fertilization and the materials given from June, 1906, until December, 1908.

TABLE III.—*Fertilizers applied in Southern Cross grove from June, 1906, to December, 1908.*

Plat.	Number of trees.	Fertilizers.	Amount per year.
			Pounds.
1	24	Acid phosphate	127
		Sulphate of potash	32
2	24	Sulphate of ammonia	62
		Sulphate of potash	32
3	24	Sulphate of ammonia	62
		Acid phosphate	127
4	24	Sulphate of ammonia	62
		Acid phosphate	127
		Sulphate of potash	32
5	24	Sulphate of ammonia	62
		Acid phosphate	127
		Muriate of potash	32
6	24	Nitrate of soda	83
		Acid phosphate	127
		Sulphate of potash	32
7	24	Dried blood	89
		Acid phosphate	127
		Sulphate of potash	32

It is shown here that there were seven plats each extending through one row of 24 trees, three of which plats were given an incomplete fertilizer [1] and four a complete fertilizer. In the plats given a complete fertilizer different materials were used to supply nitrogen and potash. The basic formula was that given plat 4 and supplied 0.775 pound phosphoric acid, 0.666 pound nitrogen, and 0.516 pound potash per tree, annually. Two applications of equal quantities were given yearly, one in June and one in December. The materials were mixed in the orchard and applied immediately. The area fertilized was beneath the branches but not in the area between the trees, thereby leaving even at the last application a guard strip of several feet between the trees.

Table IV shows the plan of application since December, 1908, when the percentage of potash in the formula was increased and the nitrogen decreased.

TABLE IV.—*Fertilizers given subplats in Southern Cross grove after 1908.*

Plat.	Number of trees.	Subplat A.		Subplat B.		Subplat C.	
		Fertilizers.	Amount per year.	Fertilizers.	Amount per year.	Fertilizers.	Amount per year.
			Pounds.		*Pounds.*		*Pounds.*
1	8	Acid phosphate	52	Acid phosphate	52	Acid phosphate	104
		Sulphate of potash	24	Sulphate of potash	48	Sulphate of potash	24
2	8	Sulphate of ammonia	18	Sulphate of ammonia	36	Sulphate of ammonia	18
		Sulphate of potash	24	Sulphate of potash	24	Sulphate of potash	48
3	8	Sulphate of ammonia	18	Sulphate of ammonia	18	Sulphate of ammonia	36
		Acid phosphate	52	Acid phosphate	104	Acid phosphate	52

[1] An incomplete fertilizer is considered here as a mixture containing but two of the three elements nitrogen, phosphoric acid, and potash, and the complete includes all three.

TABLE IV.—*Fertilizers given subplats in Southern Cross grove after 1908*—Continued.

Plat.	Number of trees.	Subplat A. Fertilizers.	Subplat A. Amount per year.	Subplat B. Fertilizers.	Subplat B. Amount per year.	Subplat C. Fertilizers.	Subplat C. Amount per year.
			Pounds.		*Pounds.*		*Pounds.*
4	8	Sulphate of ammonia.	18	Sulphate of ammonia.	18	Sulphate of ammonia.	36
		Acid phosphate	52	Acid phosphate	104	Acid phosphate	52
		Sulphate of potash	24	Sulphate of potash	48	Sulphate of potash	24
5	8	Sulphate of ammonia.	18	Sulphate of ammonia.	18	Sulphate of ammonia.	36
		Acid phosphate	52	Acid phosphate	52	Acid phosphate	52
		Muriate of potash	24	Muriate of potash	48	Muriate of potash	24
6	8	Nitrate of soda	24	Nitrate of soda	24	Nitrate of soda	48
		Acid phosphate	52	Acid phosphate	104	Acid phosphate	52
		Sulphate of potash	24	Sulphate of potash	24	Sulphate of potash	24
7	8	Dried blood	24½	Dried blood	24½	Dried blood	24½
		Acid phosphate	52	Acid phosphate	104	Acid phosphate	52
		Sulphate of potash	24	Sulphate of potash	24	Sulphate of potash	48

The basic formula for the new application was that given subplat 4A and allows 11¾ pounds per tree each year of a mixture containing 3.6 per cent nitrogen, 8 per cent phosphoric acid, and 12.8 per cent potash, and furnishes 0.45 pound nitrogen, 0.94 pound phosphoric acid, and 1.5 pounds potash per tree, or 62.62 pounds nitrogen, 131.5 pounds phosphoric acid, and 209 pounds potash annually per acre. At present selling prices[1] in Porto Rico a year's application of these unmixed materials for 1 acre is valued at $29.25.

RESULTS IN SOUTHERN CROSS GROVE.

During the progress of the experiments, observations were made to determine the effect of the fertilizer on the trees as well as on fruit production, and notes were taken regarding the foliage, trunk circumference, and general growth and thrift of the tree. In general, the plats that bore the most fruit also produced the strongest trees, although the influence of the fertilizers was less marked on the growth of the trees than on fruit production.

EFFECTS OF FERTILIZERS ON THE TREES.

Every tree in plats 4, 5, and 6—plats given a complete fertilizer—made a good growth, and all maintained a thrifty appearance. Those of plat 7 were slightly smaller than those in the other plats receiving a complete fertilizer and did not make as heavy a leaf growth. With but few exceptions the trees in the first three plats, or those given an incomplete fertilizer, did not grow as large as those in the other plats and did not produce as many leaves. The leaf production was least in plat 1, and less in plat 2 than in plat 3. These differences, however,

[1] January, 1914.

were not great, although the leaves in plats 1 and 2 were below the normal size for thrifty orange trees and not as large as in the other plats. Where complete fertilizer was given the leaves were practically uniform. Plate I shows the trees at the close of the experiments.

Tree-trunk measurements were taken 6 inches above the ground each year from 1906 to 1912 to ascertain the circumference increase under the different treatments. In Table V is given the average circumference for the first, fourth, and seventh measurements.

TABLE V.—*Tree-trunk measurements in Southern Cross grove giving average circumference at 6 inches above ground.*

Plat.	Aug., 1906.[1]	Dec., 1908.	Jan., 1912.	Average gain per tree in 3 years.	Average gain per tree in 5½ years.	Average gain per tree in 5½ years.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
1A	7.37	12.75	16.22	3.47	8.85	
1B		12.59	18.5	5.91		
1C		12.72	17.3	4.58		
2A	8.53	12.44	15.09	2.65	6.56	[2] 7.68
2B		11.56	15.06	3.5		
2C		11.75	16.06	4.31		
3A	8.28	12.56	15.9	3.34	7.62	
3B		11.7	14.37	2.67		
3C		11.53	15.09	3.56		
4A	9.72	14.06	18.1	4.04	8.38	
4B		12.09	15.84	3.75		
4C		12.09	17.78	5.69		
5A	8.87	13.56	17.62	4.06	8.75	
5B		12.7	17.03	4.33		
5C		13	18.09	5.09		[3] 8.19
6A	8.72	12.56	16.62	4.06	7.9	
6B		12.84	17.84	5		
6C		12.75	18.28	5.53		
7A	8.47	12.37	16.2	3.83	7.73	
7B		11	13.9	2.9		
7C		12.65	17.66	5.01		

[1] Measurements not recorded for subplats B and C prior to 1908.
[2] Average for incomplete fertilizer.
[3] Average for complete fertilizer.

These figures show that the growth of the tree trunk was not in proportion to the yield of fruit, at least not at the point where the measurements were taken, although the tendency was in that direction. Excepting plat 1, where the trees made the largest gain in circumference, those given complete fertilizer gained most. The differences are too small to show conclusively the superiority of one treatment over the other.

For the first few years after setting, calculations from measurements taken 6 inches above ground may be safely made, as the tree trunk at that point is not affected by the crown roots; but later, when these roots greatly increase in diameter, the trunk to this height is made angular as well as larger than the portion higher. As this is the condition with a number of the trees, the probable error in the circumference records may have been increased, although the trees developed in this way will no doubt vary equally in number in the different plats. To obtain the most reliable data on the trunk growth, measurements

FIG. 1.—TREES GIVEN INCOMPLETE FERTILIZER.

FIG. 2.—TREES GIVEN COMPLETE FERTILIZER.

FERTILIZER PLATS IN SOUTHERN CROSS GROVE.

should be made at an equal distance between roots and branches, as for trees headed low, the growth of both very soon increases the diameter and affects the shape of the trunk within several inches of their union with it.

FRUIT YIELD.

The yearly yield in number and weight of fruit for the individual plats and subplats and the estimated yield per acre and cost per tree for fertilizer for the various plats will be found in Tables VI and VII.

TABLE VI.—*Number and weight of fruit from subplats A, weight of fruits per 100, and cost of fertilizer per tree.*

Subplat.	Fertilizers.	Number of trees.	1910–11		1911–12		Average crop per tree.		Relative weight of crop as compared with subplat 4.	Weight per 100 fruits.	Cost of fertilizer per tree.
			Number of fruits.	Weight of fruit.	Number of fruits.	Weight of fruit.	Number of fruits.	Weight of fruit.			
				Pounds.		*Pounds.*		*Pounds.*		*Pounds.*	*Cents.*
1A...	Acid phosphate and sulphate of potash...	8	981	433	836	435	113.6	54.2	42.3	47.7	12.7
2A...	Sulphate of ammonia and sulphate of potash...	8	1,417	538	748	390	135.3	58	45.3	42.9	15.9
3A...	Acid phosphate and sulphate of ammonia.	8	2,021	836	1,065	514	192.9	84.4	65.9	43.7	13.6
4A...	Acid phosphate, sulphate of ammonia and sulphate of potash...	8	2,140	979	2,052	1,071	262	128.1	100	48.9	21.1
5A...	Acid phosphate, sulphate of ammonia, and muriate of potash...	8	2,913	1,256	1,815	1,015	295.5	141.9	110.8	48	20.4
6A...	Acid phosphate, nitrate of soda, and sulphate of potash...	8	1,585	825	1,654	892	202.4	107.3	83.8	53	21.7
7A...	Acid phosphate, dried blood, and sulphate of potash...	8	1,965	844	1,328	706	205.8	96.9	75.6	47.1	21.9

TABLE VII.—*Comparative yields from plats given incomplete and complete fertilizers.*

Basis of calculation of gain in yield.	1910–11		1911–12		Average crop per tree.		Percentage gain in weight of crop.
	Number of fruits.	Weight of fruit.	Number of fruits.	Weight of fruit.	Number of fruits.	Weight of fruit.	
		Pounds.		*Pounds.*		*Pounds.*	*P. ct.*
Average from three plats given incomplete fertilizer...	1,473	602.3	883	446.3	147.26	65.5	......
Average from four plats given complete fertilizer...	2,150.7	976	1,712	921	241.42	118.5	......
Gain from use of complete fertilizer...	677.7	373.7	829	474.7	94.16	53	80.9

Table VI gives the results from subplats A, divisions in which no elements were doubled. It shows the comparative value of complete and incomplete fertilizers and of different sources of nitrogen and potash and determines the elements which were limiting fruit production. As plat 4 was given the basic formula, it should be used

as the basis for comparisons in this table. Results here are so marked that the figures need little explanation.

The yield in both number and weight of fruit in the plats given the complete fertilizer was far in excess of that in plats given the incomplete, as is shown by the condensed statement of these two divisions. (See Table VII.) The average production from the four plats given a complete fertilizer was so much greater than that from the other three given only two elements that it leaves no question regarding the advantage derived from its use. The figures show a gain of 94 fruits per tree, or 65 per cent of the crop, and 53 pounds per tree, or 81 per cent of the weight of the crop.

The results of the first three plats offer data for comparing the need of the trees for nitrogen, phosphoric acid, and potash. It appears that nitrogen is most needed and that the demand for potash is less strongly felt than for either of the other two elements. The plat given phosphoric acid and nitrogen produced more than any of the other two-element plats, and the nitrogen-potash plat produced more than the one given phosphoric acid and potash. Expressed in numbers of fruit produced, omitting potash from the complete fertilizer limited the average yearly production per tree to 84 pounds; omitting phosphoric acid limited it to 58 pounds; while omitting nitrogen limited it to 54 pounds. The average yearly production per tree where a complete fertilizer was given was 118 pounds.

Table VIII, giving the yield of each subplat, shows the effect of varying the quantity of each element when applied with one or both of the other elements and gives evidence as to a formula which best provides for the needs of the crop.

TABLE VIII.— *Yield of fruit from different subplats in orchard fertilizer experiments in Southern Cross grove.*

Subplat.	Number of trees.	Fertilizers.	Amount per year.	1910–11		1911–12		Average crop per tree.	
				Number of fruits.	Weight of fruit.	Number of fruits.	Weight of fruit.	Number of fruits.	Weight of fruit.
			Pounds.		*Pounds.*		*Pounds.*		*Pounds.*
1A	8	Acid phosphate Sulphate of potash	52 24	981	433	836	435	113.6	54.2
1B	8	Acid phosphate Sulphate of potash	52 48	2,101	967	946	505	190.4	92.0
1C	8	Acid phosphate Sulphate of potash	104 24	2,123	989	1,392	721	219.7	106.9
2A	8	Sulphate of ammonia Sulphate of potash	18 24	1,417	538	748	390	135.3	58.0
2B	8	Sulphate of ammonia Sulphate of potash	36 24	913	365	622	322	95.9	42.9
2C	8	Sulphate of ammonia Sulphate of potash	18 48	1,920	969	1,103	624	188.9	99.6
3A	8	Acid phosphate Sulphate of ammonia	52 18	2,021	836	1,065	514	192.9	84.4
3B	8	Acid phosphate Sulphate of ammonia	104 18	2,254	1,010	1,257	577	219.4	99.2
3C	8	Acid phosphate Sulphate of ammonia	52 36	2,654	1,062	1,184	515	239.9	98.6

TABLE VIII.—*Yield of fruit from different subplats in orchard fertilizer experiments in Southern Cross grove*—Continued.

Sub-plat.	Number of trees.	Fertilizers.	Amount per year.	1910–11		1911–12		Average crop per tree.	
				Number of fruits.	Weight of fruit.	Number of fruits.	Weight of fruit.	Number of fruits.	Weight of fruit.
			Pounds.		*Pounds.*		*Pounds.*		*Pounds.*
4A	8	Acid phosphate Sulphate of ammonia Sulphate of potash	52 18 24	2,140	979	2,052	1,071	262.0	128.1
4B	8	Acid phosphate Sulphate of ammonia Sulphate of potash	104 18 48	2,925	1,308	1,354	675	267.4	123.9
4C	8	Acid phosphate Sulphate of ammonia Sulphate of potash	52 36 24	2,256	1,138	2,013	983	266.8	132.6
5A	8	Acid phosphate Sulphate of ammonia Muriate of potash	52 18 24	2,913	1,256	1,815	1,015	295.5	141.9
5B	8	Acid phosphate Sulphate of ammonia Muriate of potash	52 18 48	2,798	1,191	1,512	854	269.4	127.8
5C	8	Acid phosphate Sulphate of ammonia Muriate of potash	52 36 24	3,232	1,586	1,919	1,020	321.9	162.9
6A	8	Acid phosphate Nitrate of soda Sulphate of potash	52 24 24	1,585	825	1,654	892	202.4	107.2
6B	8	Acid phosphate Nitrate of soda Sulphate of potash	104 24 24	3,101	1,399	1,579	887	292.5	142.9
6C	8	Acid phosphate Nitrate of soda Sulphate of potash	52 48 24	3,176	1,584	2,102	1,137	329.9	170.1
7A	8	Acid phosphate Dried blood Sulphate of potash	52 24.5 24	1,965	844	1,328	706	205.8	96.9
7B	8	Acid phosphate Dried blood Sulphate of potash	104 24.5 24	2,401	1,044	1,779	885	261.2	120.6
7C	8	Acid phosphate Dried blood Sulphate of potash	52 24.5 48	2,848	1,359	1,841	1,026	293.1	149.1

While there are wide differences between the yields of subplats, and while consistent variations resulting from different quantities of all of the elements used are not always sufficient to warrant definite conclusions, there is a marked effect of doubling the application of nitrogen in each of the subplats. The results from doubling the quantity of nitrogen may be seen by comparing 4C, 5C, and 6C with 4A, 5A, and 6A, the fertilizer given the former series differing from that given the latter only in having twice the quantity of nitrogen. Each of the subplats C produced more than subplats A of the same plat; the average production of fruit per tree of the former was 155 pounds, and of the latter 126.

From this it is concluded that the percentage of nitrogen in the basic formula given on page 11 is too low. This conclusion is supported by the yield of subplat 4B, where with the quantity of both phosphoric acid and potash doubled the yield is not increased. As it is apparent that nitrogen is the limiting factor, and the percentage here is too low in comparison with the phosphoric acid and potash,

we can not determine definitely from these figures whether or not the percentages of the latter elements are in the most economic proportions. Light is given on this point in the discussion of the results of incomplete fertilizer which accompanies Table VI.

A notable point in Table VIII is that the greatest number or weight of fruit from any subplat given an incomplete fertilizer is less than the smallest number or weight from any subplat given a complete fertilizer with one exception, 1C compared with 7A, where the difference is slight. This proves the decided benefit of applying complete fertilizers.

The differences resulting from the various combinations of complete fertilizer on the yield of fruit are marked, and, although not in all cases leading to decisive conclusions, they furnish valuable data regarding the sources of the nitrogen and potash used. The comparative effects of applying sulphate and muriate of potash, as seen by yields of subplats 4A and 4C compared with those of 5A and 5C, sections in which the only difference in treatment was in the form of potash given, indicate the economy of using muriate as a source of potash. In two years the muriate plat produced 14 per cent more fruit in both number and weight than the sulphate plat. The low yield in 4A and the high yield of 5C, which are largely responsible for the above results, might be explained as due to an inequality in the field, as these subplats vary somewhat from neighboring ones given a similar treatment; therefore the values as indicated by the figures can not be taken too literally. No distinction between the effects of the two materials could be seen in size, thrift, or general condition of the trees, or in the flavor or quality of the fruit. Aside from giving a heavier yield, it must be remembered that muriate of potash costs the grower less than sulphate.

The results of applying dried blood and nitrate of soda may be seen by comparing subplats 7A and 7B in Table VIII with subplats 6A and 6B, where the only difference in treatment was in the form of nitrogen applied. This shows that where dried blood was given to supply the nitrogen the weight of the crop was practically 12 per cent less than where nitrate of soda was given. The comparison of the effects of sulphate of ammonia and nitrate of soda is found in the yield for subplats 4A and 4C and 6A and 6C. A difference of 3 per cent is shown here in favor of nitrate of soda. This difference might be expected to fall well within an error due to variation in field conditions, although had plat 6A shown returns equal to other sections given an equal amount of mineral nitrogen in a complete fertilizer, a sharp increase would have resulted in favor of nitrate of soda. As is shown by the yield of plat 1 and subplat 4B, nitrogen is the element that limited the production, for in plat 1 no nitro-

gen was given and a smaller quantity of fruit was harvested than from any other plat, and in subplat 4B the amounts of both phosphoric acid and potash, of the basic formula, were doubled while the yield remained the same as where neither or only one of them was doubled. Note the totals given for subplats 4A, 4B, 5A, and 5B where the average production per tree was nearly 130 pounds. This suggests that the low yield of 107 pounds for each tree of subplat 6A is probably due to a variation in field conditions which could not be seen by casual observations, or to the variation in the inclination of the trees to bear, and to the normal crop fluctuation.

LEONHARDT'S GROVE.

This orange grove is situated 3½ miles southwest of Bayamon in the rolling coastal plain that extends lengthwise of the island between the seashore and the low mountains of the interior. It is at an elevation of 100 feet above sea level and 5 miles inland, in a section where within a few years citrus fruit has grown to be one of the chief crops. The climatic conditions of this vicinity vary but little from those in others of similar elevation along the north coast of the island. The annual rainfall during 206 days with rain is 75.47 inches. August is the month of heaviest rainfall, with 9.32 inches on 20 days with rain, and February the lightest with 2.53 inches on 14 days with rain. The temperature at this point varies but little throughout the year and is very suitable to citrus growing; it has a mean temperature of 76.80° F., with the lowest mean minimum for any month at 63.10° in January, and the highest mean maximum at 89.45° in September.

The orchard slopes to the northeast, but too gradually to permit surface washing or to cause unevenness in general soil conditions. The soil is a heavy, dark, sandy clay loam for the few inches of surface which by cultivation has had vegetable matter worked into it. Underneath this is the deep, compact, yellowish-red, slightly sandy clay that is common throughout this region. The mechanical analyses made by the Bureau of Soils of the United States Department of Agriculture and the chemical analyses made by the chemistry department of this station present an accurate statement as to the character of the land on which the orchard experiments have been conducted. (See Tables I and II.) This is the typical soil of this part of the island, and, as is readily seen from the above description, it is not an ideal one for citrus culture, because of being too compact to allow good drainage or aeration and because some of the food elements are insufficient to maintain a good tree development for any long term of years. As the subsoil drainage is poor, the greater part of the citrus-root system is forced into the upper few inches of soil, though occasional roots are found at a depth of 6 feet.

PREPARATION AND PLANTING OF THE ORCHARD.

The vegetation on the orchard site at the time of its selection was grass and a number of species of trees, including various legumes, an occasional mango tree, and thickets of pomarosa (*Jambosa jambolana*) which grew to a height of 10 to 12 feet. In clearing the land, the tree trunks and larger branches were hauled away and the smaller branches and undergrowth burned on the field. The larger stumps, but not all, were removed. For tree planting, holes 18 inches square by 15 inches deep were dug 25 feet apart in squares. Nursery trees from this vicinity were set. This planting included the trees of rows 1, 3, 5, 7, and 9 in diagram on page 19. During the following 10 months these trees were given but little attention and but three-fourths of a pound of a complete fertilizer each. At the end of this time the heavy growth of wild vegetation which grew after the trees were set was removed, strips of land between the tree rows were plowed, and other rows of trees, in which the trees were placed 25 feet apart in the row, were set between the rows of the former planting. Placing the trees of the new planting halfway between those of the former gave 139 to the acre; therefore the shortest distance between any two trees was 17 feet 8 inches. For the next five years, or until the tree branches interfered, the orchard was given a thorough plowing once a year, followed at intervals, during the dry season, by the harrow and cultivator. From this time cultivation, which was limited by the branches of one row of trees meeting those of the next, included the removing of grass and weeds and the working of fertilizer into the soil. This work was done with hoes. The cultivation given the experimental plats was the same as that in the commercial orchard of which it was a part, except that leguminous cover crops were not allowed to grow. The oranges in these experiments are of the native sweet type, except for a few navel trees. The latter produced their first full crop during the season of 1910–11, and the fruit was considered with that of the remainder of the plat. Although this was a normal crop, the next year the trees were seen to be so inferior to the other trees in size, vigor, and productiveness that they were not included in the figures for 1911–12. These trees are indicated in the orchard diagram. During the first years after setting a few trees died, and those reset in these places were not considered in the experiments. The experimental field shown in Diagram II has nine plats.

Diagram II.—*Showing arrangement of trees and plats in Leonhardt's grove.*[1]

Plat	Trees
1.	△ △ △ △ △ △ △ △ △ △ △ △
2.	○ ○ ○ ○ ○ ○ ○ ○ × ×[2] × ×
	× × × × ⊕ ⊕ ⊕ ⊕[3] ⊕ ⊕ ⊕[3] ⊕[3]
3.	○ ○ ○ ○ ○ ○ ○[2] ○ × × × ×[2]
	× × × × ⊕ ⊕ ⊕ ⊕ ⊕[2] ⊕ ⊕ ⊕
4.	○ ○ ○ ○ ○ ○ ○[2] ○ × × ×[3] ×[2]
	× × × × ⊕ ⊕ ⊕ ⊕ ⊕[2] ⊕ ⊕ ⊕
5.	○ ○ ○ ○ ○ ○ ○ ○ × × ×[3] ×[2]
	× × × × ⊕ ⊕ ⊕ ⊕ ⊕ ⊕ ⊕ ⊕
6.	○ ○ ○ ○ ○ ○ ○ ○ × × × ×
	× × × × ⊕ ⊕ ⊕ ⊕ ⊕ ⊕ ⊕ ⊕
7.	○ ○ ○ ○ ○ ○ ○ ○ × × × ×
	× × × × ⊕ ⊕ ⊕ ⊕ ⊕[2] ⊕ ⊕ ⊕
8.	○ ○ ○ ○ ○ ○ ○ ○ × × × ×
	× × × × ⊕ ⊕ ⊕ ⊕ ⊕ ⊕ ⊕ ⊕
9.	△ △ △ △ △ △ △ △ △ △ △ △

Numbers 1 and 9 were single rows of 12 trees each, which were not fertilized but left for checks. All other plats occupied two rows, with a total of 24 trees in each plat. Plats 2, 3, and 4 were given an incomplete fertilizer, or one containing but two elements each, and the remaining four plats were given all three elements. The variation in the mixture given them consisted in having nitrogen and potash derived from different sources. The basic formula is found in plat 5 and provides for 0.519 pound nitrogen, 0.766 pound phosphoric acid, and 0.666 pound potash per tree yearly. Ten pounds of this mixture, which contains approximately 5 per cent nitrogen, 7½ per cent phosphoric acid, and 6½ per cent potash, was given each tree each year in two applications, one in June and the other in December.

Table IX.—*Fertilizers applied each year in Leonhardt's grove from June, 1906, to June, 1908.*

Plat.	Number of trees.	Fertilizers.	Amount per year.
			Pounds.
1	12	No fertilizer	....
2	24	Acid phosphate	127
		Sulphate of potash	32
3	24	Nitrate of soda	83
		Sulphate of potash	32
4	24	Nitrate of soda	83
		Acid phosphate	127
5	24	Nitrate of soda	83
		Acid phosphate	127
		Sulphate of potash	32
6	24	Nitrate of soda	83
		Acid phosphate	127
		Muriate of potash	32
7	24	Sulphate of ammonia	62
		Acid phosphate	127
		Sulphate of potash	32
8	24	Nitrate of soda	83
		Acid phosphate	127
		Sulphate of potash	32
		Lime 8 pounds per tree.	
9	12	No fertilizer.[4]	

[1] Plats 1 and 9, checks. Plats 2 to 8, ○ indicates trees of subplats A, × of subplats B, and ⊕ of subplats C.
[2] Trees of navel variety.
[3] Trees died after setting.
[4] Discontinued 1908.

The above mixture and quantity applied was considered suitable for trees which had not reached bearing age. In 1908, when the trees were large but producing only a small quantity of fruit, the amount of fertilizer was increased and the formula changed to one having a lower nitrogen content and a higher percentage of potash.

The new basic formula, containing approximately 3 per cent of nitrogen, 8 per cent phosphoric acid, and 12 per cent of potash, applied at the rate of 21⅛ pounds per tree, supplies 0.75 pound of nitrogen, 1.61 pounds of phosphoric acid, and 2.50 pounds of potash per tree.

As the fertilizers were exerting a marked influence on the growth and productiveness of the trees and apparently on the flavor of the fruit, it seemed advisable to change the plan of application so as to give a better opportunity for studying the effects of the different ingredients. Each plat was divided into 3 subplats of 8 trees each. Subplats A were given the same ingredients as in former applications, while to B and C were given the same plus an equal amount of one of the ingredients. Table X shows the revised treatment given to the same rows that are shown in Diagram II.

TABLE X.—*Fertilizers applied each year after June, 1908.*

Plat.	Number of trees.	Subplat A. Fertilizers.	Subplat A. Amount per year.	Subplat B. Fertilizers.	Subplat B. Amount per year.	Subplat C. Fertilizers.	Subplat C. Amount per year.
			Pounds.		*Pounds.*		*Pounds.*
1	......	No fertilizer[1]	....	....	....	....	....
2	8	Acid phosphate....	89	Acid phosphate....	89	Acid phosphate....	178
		Sulphate of potash.	40	Sulphate of potash.	80	Sulphate of potash.	40
3	8	Nitrate of soda.....	40	Nitrate of soda.....	80	Nitrate of soda.....	40
		Sulphate of potash.	40	Sulphate of potash.	40	Sulphate of potash.	80
4	8	Nitrate of soda.....	40	Nitrate of soda.....	40	Nitrate of soda.....	80
		Acid phosphate....	89	Acid phosphate....	178	Acid phosphate....	89
5	8	Nitrate of soda.....	40	Nitrate of soda.....	40	Nitrate of soda.....	80
		Acid phosphate....	89	Acid phosphate....	89	Acid phosphate....	89
		Sulphate of potash.	40	Sulphate of potash.	80	Sulphate of potash.	40
6	8	Nitrate of soda.....	40	Nitrate of soda.....	40	Nitrate of soda.....	80
		Acid phosphate....	89	Acid phosphate....	89	Acid phosphate....	89
		Muriate of potash..	40	Muriate of potash..	80	Muriate of potash..	40
7	8	Sulphate of ammonia.	30	Sulphate of ammonia.	30	Sulphate of ammonia.	60
		Acid phosphate....	89	Acid phosphate....	178	Acid phosphate....	89
		Sulphate of potash.	40	Sulphate of potash.	40	Sulphate of potash.	40
8	8	Nitrate of soda.....	40	Nitrate of soda.....	40	Nitrate of soda.....	80
		Acid phosphate....	89	Acid phosphate....	178	Acid phosphate....	89
		Sulphate of potash.	40	Sulphate of potash.	40	Sulphate of potash.	40
		Lime, 10 pounds per tree.[2]					

[1] Includes first 4 trees.

[2] Applied until 1910.

TREE-TRUNK GROWTH.

Table XI gives the record of three of the annual tree-trunk measurements and shows the average gain in circumference and the comparative gain made in plats given incomplete fertilizer and those given complete. While the period over which the measurements in

subplats B and C were taken was short, and the gains too conflicting to permit of conclusions as to the influence of the fertilizers on the rate of growth, that for subplat A extends over five years, and the records reveal marked differences in the rate of growth.

These figures show that the growth made in the plats given a complete fertilizer was nearly equal, that each gained more in circumference than any of the plats given an incomplete fertilizer, and that in the plats given an incomplete fertilizer the growth was nearly uniform. This gain made by the trees given a complete fertilizer was 17.43 inches in circumference in the five years, which was 2.2 inches more than was made by those given but two elements, and 8.4 inches more than, or nearly twice, that made by unfertilized trees.

TABLE XI.— *Tree-trunk measurements in Leonhardt's grove giving average circumference at 6 inches above the ground.*

Plat.	January, 1907.[1]	December, 1908.	January, 1912.	Average gain per tree in 3 years.	Average gain per tree in 5 years.	Average gain per tree in 5 years.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
1A	6.69	11.44	16.75	5.31	9.06	9.06
2A	7.25	13.72	22.9	9.18	15.65	
2B		13.22	18.5	5.28		
2C		11.9	18.7	6.8		
3A	7.81	16.1	22.6	6.5	14.79	[2] 15.23
3 B		14.37	20	5.63		
3C		14.1	21.2	7.1		
4A	7.24	16.5	22.5	6	15.26	
4B		16	23.9	7.9		
4C		13.85	20.5	6.65		
5A	7.97	18.87	25.2	6.33	17.23	
5B		16.97	22.8	5.83		
5C		14.87	23.8	8.93		
6A	8.4	17.5	25.9	8.4	17.5	
6B		15.72	23.2	7.48		
6C		16.25	23.6	7.35		[3] 17.43
7A	8.03	18.03	26.3	8.27	18.27	
7B		16.93	24.4	7.47		
7C		15.97	26.6	10.63		
8A	8.78	17.9	25.5	7.6	16.72	
8B		18.15	26.7	8.55		
8C		16.12	26.2	10.08		

[1] Measurements in subplats B and C not recorded prior to 1908.
[2] Average for incomplete fertilizer.
[3] Average for complete fertilizer.

HARVEST RESULTS.

When the experiment was started, the rows on either side of the fertilized plats, rows 1 and 9, were left unfertilized for checks; but in a few years, when it was seen that these rows would be almost a total loss to the grove owners if not fertilized, they were discontinued as experimental plats, except that four trees in plat 1 were retained as checks. These trees of the check plats were making such unsatisfactory growth that fertilization was seen to be imperative if the orchard was to be commercially profitable, and the experiments were continued to determine what mixture would give the best results rather than to compare the fertilized and unfertilized areas.

It is sufficient to note that the check trees made a slow, unsatisfactory growth and produced only one-fourth as much fruit as the plats given a complete fertilizer. Before the crop of 1910–11, which was the first crop of consequence, these trees, though growing slowly and having very small leaves, maintained a good color, but after this harvest and until the conclusion of the experiment there was a poor growth of leaves and many of the leaves had a yellowish color. There was practically no growth of branches. The starving condition was very apparent. The decaying vegetation worked into the soil before setting the orchard and during the first years of its cultivation, and the water-soluble minerals in the soil were sufficient to support a normal wood growth and maintain normal leaves. A thrifty wood growth does not draw strongly on the soil, but the added crop of fruit, which when ripened is removed from the orchard, necessitates a much larger quantity of plant food if the trees are to retain their vigor. The thrifty growth of young trees causes many growers to believe their soil sufficiently rich to produce an orchard, and they delay fertilization until their trees have been seriously injured by starvation.

TABLE XII.—*Number and weight of fruit harvested from subplats A, weight of fruit per 100, and cost of fertilizer applied.*

Subplat.	Number of trees.	Fertilizers.	1910–11		1911–12		Average crop per tree.		Relative weight of crop, as compared with subplat 5.	Weight per 100 fruit.	Value of fertilizer.[1]
			Number of fruits.	Weight of fruit.	Number of fruits.	Weight of fruit.	Number of fruits.	Weight of fruit.			
				Lbs.		*Lbs.*		*Lbs.*		*Lbs.*	
1	4	Check	934	508	244	157	147.2	83	24.9	56.4	......
2A	8	Acid phosphate and sulphate of potash	2,548	1,656	2,135	1,337	292.6	187	56	63.9	$1.71
3A	[2] 8	Sulphate cf potash and nitrate of soda	4,125	2,252	1,568	1,015	355.7	204.2	61.3	57.4	2.20
4A	8	Acid phosphate and nitrate of soda.	5,181	2,498	2,787	1,521	498	251	75.3	50.4	1.91
5A	8	Acid phosphate, nitrate of soda, and sulphate of potash	5,533	3,150	3,234	2,188	547.9	333.6	100	60.9	2.91
6A	8	Acid phosphate, nitrate of soda, and muriate of potash	5,907	3,096	3,120	2,002	564	318.6	95.5	56.5	2.80
7A	8	Acid phosphate, sulphate of ammonia, and sulphate of potash	5,766	3,272	3,130	2,147	556	338.6	101.5	60.9	2.84
8A	8	Acid phosphate, nitrate of soda, and sulphate of potash [3]	5,455	2,793	1,806	1,146	453.7	246.2	73.8	54.2	2.91

[1] Value calculated from unmixed materials in San Juan, January, 1914.
[2] One tree of this subplat died. Figures calculated from yield of seven trees.
[3] Lime applied until 1910.

Table XII gives the yield in pounds and number of fruits of the five harvests in 1910–11 and the three in 1911–12 in subplats A, the sections in which no element was doubled. Except in the case of subplat 8A, where it is believed the small crop of 1911–12 was due to an abnormal fluctuation in yield on the part of three trees which had practically nothing, the conclusions indicated by the records are, we believe, very dependable.

The striking differences in yield will show the influence of the different fertilizing elements, the value of which is calculated by comparison with plat 5, which was given the basic formula. As in the other grove, nitrogen is the element most needed for fruit production. In subplat 2A where only phosphoric acid and potash were given, the quantity of fruit produced was below that of either plat where nitrogen was given with one other element, and but little more than half the quantity borne by the plat where 5 pounds of nitrate of soda per tree was added to materials given subplat 2A. Phosphoric acid is next in importance, as is proved by the fact that the trees to which this element was not applied yielded only 61.3 per cent of that where 11 pounds per tree of acid phosphate was added to the ingredients given. The shortage of potash seemed to be felt less plainly than that of either of the other two elements, for the plat given no potash—subplat 4A—produced nearly 23 per cent more than where phosphoric acid was omitted and 34 per cent more than where nitrogen was omitted; although where 5 pounds of sulphate of potash per tree was given with the other elements the yield was 33 per cent greater than where it was omitted. The important results shown in this table prove the need of all three ingredients, or a complete fertilizer, and give evidence as to the proportions of the ingredients which will give best results.

Among the plats given a complete fertilizer the differences were small except in the results of subplat 8A, which are explained above. The average yield of plats given complete and incomplete fertilizers is summarized in Table XIII.

Table XIII.—*Comparative yields from plats given incomplete and complete fertilizers.*

Basis of calculation of gain in yield.	1910–11		1911–12		Average crop.		Average crop per tree.		Percentage gain in weight of crop.
	Number of fruits.	Weight of fruit.	Number of fruits.	Weight of fruit.	Number of fruits.	Weight of fruit.	Number of fruits.	Weight of fruit.	
		Lbs.		*Lbs.*		*Lbs.*		*Lbs.*	*Per ct.*
Average from 3 plats given incomplete fertilizer	3,951	2,135	2,163	1,291	3,057	1,713	382.1	214.1	
Average of 4 plats given complete fertilizer	5,665	3,078	2,822	1,871	4,243	2,474	530.4	309.2	
Gain from use of complete fertilizer	1,714	943	659	580	1,186	761	148.3	95.1	44.4

This table shows that the average production of the plats given complete fertilizers was 44 per cent greater than those given incomplete, a gain of over 13,000 pounds of fruit per acre.

Table XIV gives the yield in pounds and number of fruits of the five harvests in 1910–11 and the three in 1911–12 for each of the subplats, and an average of the two crops.

TABLE XIV.—*Yield of fruit from different subplats in orchard-fertilizer experiments in Leonhardt's grove.*

Sub-plat.	Num-ber of trees.	Fertilizers.	Amount per year.	1910–11		1911–12		Average crop per tree.	
				Num-ber of fruits.	Weight of fruit.	Num-ber of fruits.	Weight of fruit.	Num-ber of fruits.	Weight of fruit.
			Pounds.		*Pounds.*		*Pounds.*		*Pounds.*
1	4	Check	....	934	508	244	157	147.2	83.1
2A	8	Acid phosphate Sulphate of potash	89 40	2,548	1,656	2,135	1,337	292.7	187.5
	8	Acid phosphate Sulphate of potash	89 80	3,446	1,835	[1] 492	328	246	135.2
2C	[2] 8	Acid phosphate Sulphate of potash	178 40	2,974	1,949	1,462	1,076	277	189
3A	8	Sulphate of potash Nitrate of soda	40 40	4,125	2,252	[1] 1,568	1,015	355.8	204.2
3B	8	Sulphate of potash Nitrate of soda	40 80	3,044	1,380	[1] 797	507	240	117.9
3C	8	Sulphate of potash Nitrate of soda	80 40	3,014	1,579	[1] 825	626	239.9	137.7
4A	8	Acid phosphate Nitrate of soda	89 40	5,181	2,498	2,787	1,521	498	151.2
4B	[3] 8	Acid phosphate Nitrate of soda	178 40	7,128	3,268	1,281	764	525.6	252
4C	8	Acid phosphate Nitrate of soda	89 80	3,436	1,772	1,327	781	297.6	159.6
5A	8	Acid phosphate Nitrate of soda Sulphate of potash	89 40 40	5,533	3,150	3,234	2,188	547.9	333.6
5B	8	Acid phosphate Nitrate of soda Sulphate of potash	89 40 80	4,527	2,301	[1] 1,768	1,243	393.4	221.5
5C	8	Acid phosphate Nitrate of soda Sulphate of potash	89 80 40	4,594	2,739	2,977	2,026	473.2	279.8
6A	8	Acid phosphate Nitrate of soda Muriate of potash	89 40 40	5,907	3,096	3,120	2,002	564.2	318.6
6B	8	Acid phosphate Nitrate of soda Muriate of potash	89 40 80	5,255	3,174	2,567	1,691	488.8	304
6C	8	Acid phosphate Nitrate of soda Muriate of potash	89 80 40	4,627	2,704	2,832	1,862	466.2	285
7A	8	Acid phosphate Sulphate of ammonia Sulphate of potash	89 30 40	5,766	3,272	3,130	2,147	556	338.7
7B	8	Acid phosphate Sulphate of ammonia Sulphate of potash	187 30 40	4,559	2,421	2,991	1,933	472	272
7C	8	Acid phosphate Sulphate of ammonia Sulphate of potash	89 60 40	3,700	2,102	[1] 3,520	2,360	451.2	279
8A	8	Acid phosphate Nitrate of soda Sulphate of potash	89 40 40	5,455	2,793	1,806	1,146	453.8	246.2
8B	8	Acid phosphate Nitrate of soda Sulphate of potash	187 40 40	4,734	2,598	2,930	1,873	479	279.4
8C	8	Acid phosphate Nitrate of soda Sulphate of potash	89 80 40	6,429	3,316	2,927	2,201	584.5	344.8

[1] Figures calculated from yield of 7 trees; 1 tree of navel variety not considered.
[2] Figures calculated from yield of 5 trees; 3 trees died while young; crops from those set later were not considered in experiment.
[3] Figures calculated from yield of 7 trees.

The 1911–12 crop was not as heavy as the previous one, owing to the natural fluctuation in yield common to practically all tree fruits. The variation in yield of individual trees was also pronounced; a few trees bore practically nothing. This unevenness was no doubt responsible for the small crop from certain subplats, notably 8A, 5B, and 2B, and causes apparent contradictions.

While variations shown in Table XIV are too great to allow a definite statement as to the effect of increasing the percentage of one element in every case, general conclusions may be drawn. The total yield from the subplats A was greater than that from either B or C, which had the same fertilizer as A plus an equal amount of one of its elements, and in each individual plat the yield in A was greater than in B or C except in 2 and 8. In plat 2 the yield was practically equal. This shows clearly that no one element was a decided limiting factor and that the proportions of the elements applied were closely meeting the needs of the trees.

Some evidence, however, as to a possible improvement in the formula may be found by a study of the results of increasing the percentage of the various elements in the different subplats. In five of the six subplats where the quantity of nitrogen was doubled, the weight of fruit was less than in the corresponding subplats where the basic formula, carrying 5 pounds of nitrate of soda per tree was given. The same result is found with the potash as regards yield, as all four subplats given a double portion of potash fell below subplat A of the same plat in number of fruit produced. Where the quantity of phosphoric acid was doubled an increase in yield resulted in three out of the four subplats. This indicates that for fruit production under these conditions, the proportion of nitrogen applied in the basic formula is sufficient for trees of this age. It could probably be slightly lowered profitably, for when doubled it gave actually less fruit. The same is true with potash, but the percentage of phosphoric acid should be increased. Only by carefully studying the progress of the trees can the formula for succeeding years be determined; but to meet the needs of this grove at this age we would recommend a formula carrying 2½ per cent of nitrogen, 12 per cent of phosphoric acid, and 12 per cent of potash. While a lower potash content might be sufficient for crop production, the excess will be advantageous in increasing the weight of the fruit.

WEIGHT OF FRUIT.

In the last column of Table XII will be found the average weight per 100 fruits of each plat. A marked difference in weight of fruit appears in the plats given an incomplete fertilizer, proving the effects of the different elements on the weight of the fruit. The heaviest fruits were borne by trees given no nitrogen, and the lightest by those given nitrogen and phosphoric acid but no potash. This is the reverse of the effects of these elements on the total production. Where no potash was given in the fertilizer, the weight of 100 fruits was 50.4 pounds, or 7 pounds less than that of the plat given potash and nitrogen, and 13.5 pounds less than the one given potash and phosphoric acid. This leaves no doubt as to the necessity for applying potash if heavy fruits are desired. Where nitrogen is omitted

from the fertilizer the weight of the fruit is much heavier than in any of the plats where it is applied. No measurements were recorded which show the size of the fruit, but numerous casual observations were made resulting in a belief that there was but little if any difference. Where no potash was given the skin appeared to be slightly thicker while it was not as closely adhering as where no nitrogen was given.

EFFECT OF DIFFERENT FERTILIZER CONSTITUENTS.

The experiments were continued one year later in plats 5 and 6 of this grove for the purpose of testing more thoroughly the comparative effects of muriate and sulphate of potash.

TABLE XV.—*Yields from plats where potash was applied in form of muriate and of sulphate.*

Plat.	Fertilizers.	1910-11		1911-12		1912-13	
		Number of fruits.	Weight of fruit.	Number of fruits.	Weight of fruit.	Number of fruits.	Weight of fruit.
			Pounds.		*Pounds.*		*Pounds.*
5	Sulphate of potash, nitrate of soda, and acid phosphate	14,656	8,190	7,979	5,457	11,280	(1)
6	Muriate of potash, nitrate of soda, and acid phosphate	15,789	8,974	8,519	5,555	10,971	(1)

Plat.	Fertilizers.	Average crop.		Average crop per tree.		Percentage gain from use of muriate of potash.	
		Number of fruits.	Weight of fruit.	Number of fruits.	Weight of fruit.	Number of fruits.	Weight of fruit.
			Pounds.		*Pounds.*	*Per cent.*	*Per cent.*
5	Sulphate of potash, nitrate of soda, and acid phosphate	11,304.3	6,823	471	284		
6	Muriate of potash, nitrate of soda, and acid phosphate	11,759	7,264	489	302	3.8	6.3

[1] Not recorded.

In Table XV it may be seen that where muriate of potash was given the average weight of a crop per tree was 302 pounds, and where the sulphate was given, 284 pounds, a gain of 6.3 per cent for the muriate. In regard to the number of fruits harvested, the muriate of potash yielded 3.8 per cent more than the sulphate. The weight of the fruit was not recorded for the 1912-13 crop.

These averages correspond so closely that the differences may be attributed to a probable error in field conditions, for the number and weight of fruits produced indicate that one form of potash tried is not superior to the other. Numerous examinations and comparisons were made of the fruit from the two plats, but differences in quality, texture, or flavor were not detected. Calculated at prices quoted in Porto Rico, the muriate of potash in this formula applied costs per tree 1¼ cents less than the sulphate.

The differences in effect on the yield resulting from the application of nitrate of soda and sulphate of ammonia were very small, as will be seen by comparing the yields in subplats 5A and 5C with those of 7A and 7C in Table XIV. These differences are too small to prove an advantage of either. Various tests failed to disclose that the form of nitrogen used affected in any way the flavor, texture, or color of the fruit.

An important question, and one to be decided by more extensive experiments, arises from the results of the nitrogen and phosphoric-acid applications. Why is the demand for phosphoric acid so high as compared with that for nitrogen? In Table XII it is clearly shown that nitrogen is of greater importance to fruit production than is phosphoric acid or potash; and as shown in the accompanying tables nitrogen is used in greater quantities than phosphoric acid by citrus trees in the production of fruit, leaves, and wood. Still, the quantity of nitrogen in the formula supplying 3 per cent of nitrogen, 8 per cent of phosphoric acid, and 12 per cent of potash is sufficient, while increasing the percentage of phosphoric acid proves beneficial.

TABLE XVI.—*Analysis of orange fruit, leaves, and wood.*

Parts of plant.	Nitrogen.	Phosphoric acid.	Potash.
	Per cent.	*Per cent.*	*Per cent.*
Whole fruit[1]	0.118	0.054	0.293
Leaves[2]	.70	.10	.38
Wood[2]	.70	.50	.73

[1] Florida Sta. Rpt. 1909, p. XXXII.
[2] Aliño, Jour. Roy. Hort. Soc. [London], 25 (1901), No. 3, pp. 341–352.

TABLE XVII.—*Elements supplied and removed by orange crop.*

How supplied and removed.	Nitrogen.	Phosphoric acid.	Potash.
	Pounds.	*Pounds.*	*Pounds.*
Supplied by basic formula each year per acre	104.27	224.22	347.5
Removed by fruit produced by average crop estimated from above analysis	50.7	23.2	125.9

GRAPEFRUIT GROVE NEAR MANATI, P. R.

A grapefruit grove is situated 2 miles northeast of Manati, 2 miles from the sea, and 75 feet above its level. The orchard site is a gently rolling area lying between low, small, limestone hills, which break the otherwise almost level coastal plain. The surface soil is a very sandy red clay, which in some places is almost pure sand, and is underlain at a depth of from a few inches to a few feet by a much heavier, yellowish-red, sandy clay. The local weather conditions are practically the same as described for the other orchards, the mean temperature being 77.3° F. with a range of 20.3°. The

rainfall of a year totaled 69 inches, which fell in 184 days. These conditions seem to be specially well suited to grapefruit cultivation and result in the constant increase in the industry throughout this section.

The experimental plats selected in this grove were seven in number, with a single row of 24 trees in each plat, excepting the check plat, which had but four trees. The arrangement of trees and plats was the same as shown in Diagram I, except that there was an additional check plat in this grove. The trees were set in the year 1902 and were bearing a small crop in 1906, when the experiments were started. The trees in the plats selected had made a uniformly thrifty growth and were apparently of the same size and vigor. From the time of setting the grove until the conclusion of the experiments clean cultivation was practiced, and the surface soil was stirred often enough to keep it in good physical condition. The amounts of fertilizer materials which were applied yearly in two applications from June, 1906, to December, 1908, are given in Table XVIII. The basic formula is found in the fertilizer given plat 5 and allows for 0.57 pound nitrogen, 1.18 pounds phosphoric acid, and 1.8 pounds potash for each tree, annually.

TABLE XVIII.—*Fertilizers applied annually in grove near Manati from 1906 to 1908.*

Plats.	Number of trees.	Fertilizers.	Amount per year.	Plats.	Number of trees.	Fertilizers.	Amount per year.
			Pounds.				*Pounds.*
1	4	Check	....	6	24	Acid phosphate	195
2	24	Acid phosphate	195			Sulphate of potash	88
		Muriate of potash	88			Nitrate of soda	92
3	24	Muriate of potash	88	7	24	Acid phosphate	195
		Nitrate of soda	92			Muriate of potash	88
4	24	Acid phosphate	195			Dried blood	98
		Nitrate of soda	92				
5	24	Acid phosphate	195				
		Muriate of potash	88				
		Nitrate of soda	92				

TABLE XIX.—*Fertilizers given subplats in grove near Manati annually after 1908.*

Plat.	Number of trees.	Subplat A.		Subplat B.		Subplat C.	
		Fertilizers.	Amount per year.	Fertilizers.	Amount per year.	Fertilizers.	Amount per year.
			Pounds.		*Pounds.*		*Pounds.*
1	4	Check	....	....	....	....	....
2	8	Acid phosphate	89	Acid phosphate	89	Acid phosphate	178
		Muriate of potash	40	Muriate of potash	80	Muriate of potash	40
3	8	Muriate of potash	40	Muriate of potash	40	Muriate of potash	80
		Nitrate of soda	40	Nitrate of soda	80	Nitrate of soda	40
4	8	Acid phosphate	89	Acid phosphate	178	Acid phosphate	89
		Nitrate of soda	40	Nitrate of soda	40	Nitrate of soda	80
5	8	Acid phosphate	89	Acid phosphate	89	Acid phosphate	89
		Nitrate of soda	40	Nitrate of soda	40	Nitrate of soda	80
		Muriate of potash	40	Muriate of potash	80	Muriate of potash	40
6	8	Acid phosphate	89	Acid phosphate	89	Acid phosphate	89
		Nitrate of soda	40	Nitrate of soda	80	Nitrate of soda	40
		Sulphate of potash	40	Sulphate of potash	40	Sulphate of potash	80
7	8	Acid phosphate	89	Acid phosphate	178	Acid phosphate	89
		Dried blood	41½	Dried blood	41½	Dried blood	83
		Muriate of potash	40	Muriate of potash	40	Muriate of potash	40

FIG. 1.—TREES GIVEN INCOMPLETE FERTILIZER.

FIG. 2.—TREES GIVEN COMPLETE FERTILIZER.

FERTILIZER PLATS IN GROVE NEAR MANATI.

Table XIX shows the quantities of materials applied from December, 1908, when the plats were divided into subplats, until the close of the experiment in December, 1910. The basic formula for the latter applications is found in the fertilizer given subplat 5A and provides for 0.75 pound nitrogen, 1.61 pounds phosphoric acid, and 2.5 pounds potash yearly for each tree.

EFFECTS OF FERTILIZATION ON GROWTH OF TREE TRUNKS.[1]

Practically the same results have been obtained in the measurements of the tree trunks in this as in the other experimental orchards, namely, the gain made by the trees in plats given a complete fertilizer was considerably more than in those given only two elements and was almost uniform for the three plats.

TABLE XX.—*Tree-trunk measurements in grove near Manati giving average circumference at 6 inches above ground.*

Plat.	Feb., 1907.[1]	Dec., 1908.	Jan., 1911.	Average growth per tree in 2 years.	Average growth per tree in 4 years.	Average growth per tree in 4 years.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
1 Check	[2] 11.75	13.94	16	2.06	[3] 4.25	[3] 4.25
2A	12.28	15.15	17.69	2.55	5.41	
2B		15.84	19.25	3.41		
2C		18.47	20.50	2.03		
3A	12.15	15.28	18.1	2.82	5.95	[4] 6.11
3B		16.37	19.94	3.57		
3C		18.53	23.56	5.03		
4A	13.09	16.20	20.06	3.86	6.97	
4B		16.71	21.50	4.79		
4C		18.62	21.4	2.78		
5A	12.34	16.75	19.75	3	7.41	
5B		15.61	19.31	3.70		
5C		16.68	19.57	2.89		
6A	12	16.47	20	3.53	8	[5] 8.03
6B		18.22	20.13	1.91		
6C		16.34	18.38	2.04		
7A	14.06	19	22.75	3.75	8.69	
7B		15.03	17.75	2.72		
7C		16.12	18.31	2.19		

[1] Measurements in subplats B and C not recorded prior to 1908.
[2] Measurements recorded July, 1907.
[3] Gain for 3½ years.
[4] Average for incomplete fertilizer.
[5] Average for complete fertilizer.

An examination of Table XX shows that the average trunk growth per tree in three and one-half years made by the unfertilized trees was 4.25 inches, that that in subplats A given an incomplete fertilizer was 6.11 inches, and the growth in four years for those in subplats A given a complete fertilizer was 8.03 inches. The trunk growth made by trees given a complete fertilizer was nearly twice that made by those in the check plat and decidedly more than that made by those given an incomplete fertilizer. Photographs shown in Plate II illustrate the marked difference in size of trees as a result of different fertilizers applied. For the two years in which measurements were

[1] Fruit yields were not recorded.

taken in subplats B and C, the differences in growth of these trees compared with those of the plat given a mixture prescribed by the basic formula were too small to prove the advantage of doubling the quantity of an element. In the plats given a complete fertilizer the trees made a good growth from the time the experiments were started until their close. The leaves were well proportioned in size and of a dark-green color, indicating that the trees were in a thrifty condition. The leaves of trees in the check plat and in plats 2, 3, and 4, those given but two elements each, were not as large as in the plats given three elements; and those of plats 1, 2, and 3 were somewhat lighter in color than those in the other plats, a difference which was most noticeable during periods of drought. In plat 2, where no nitrogen was given, there was throughout the year a small percentage of leaves of a yellowish color, and at times when the trees needed rain half or more of the leaves were of this color. This condition was most apparent in subplat 2B, and it appeared that the unthrifty color was intensified by drought and that improvement was much slower following rains than in the other subplats.

EFFECT OF FERTILIZERS ON THE FLAVOR OF THE FRUIT.

Flavor tests of fruit made in 1908 led to the belief that there was a marked difference in the fruit from the plats receiving different fertilizer materials. The greatest difference was thought to be between the plat given no potash and those receiving a complete fertilizer. The fruit in the latter seemed to be much more rich and to lack the insipid quality of the former. The same differences, though less marked, were observed in favor of the plats given a complete fertilizer over the other plats given but two elements.

During the past two seasons fruit from the various plats was tested by experienced citrus growers with conflicting opinions as to the influence of the different fertilizers on the flavor. Our attempts to discover constant differences in flavor between fruit of different plats have failed. Although there are many advocates of theories regarding the influence of different fertilizer materials on the flavor of citrus fruits, it should be remembered that the casual observer is seldom sufficiently cautious for his conclusions to be valuable, and the opinion of only those who are experienced in this work should be considered. It is important that specimens of the same degree of maturity be selected for testing so that the quantity of sugar or acid may not bias the judgment as to richness or appear out of true proportion. This selection is very difficult, as the color of the fruit is influenced by its position on the tree, by the amount of sunlight it receives, by the possible hastening of maturity due to fertilization, by individual tree variation, and by the thriftiness and health of

the tree. As the apex of the fruit has much more sugar and richness than the base, great care must be taken that sections be cut from similar parts of the different fruits to be tested. Also, the acid and flavor of one specimen remaining in the mouth often causes one to misjudge the remaining specimens.

SEASON OF RIPENING OF THE FRUIT.

Pickings were not made at regular intervals, but at times when in one or more plats there was sufficient fruit of marketable condition to warrant a commercial harvest. The harvesting was always done by experienced grove laborers, who were instructed to gather all fruit in condition for shipment. The weight of the fruit for each picking was calculated as a percentage of the year's crop. The calculations were made for each subplat in the experimental field, and the resulting figures indicate that no mixture of fertilizer used exerted an influence hastening or retarding the ripening of the fruit. The season of ripening for most subplats was almost the same, and the greatest differences showed no consistent change in the ripening season which could be credited to the fertilizer given them. In the plat given no fertilizer the fruit ripened much earlier both years in which the yields were recorded than in any plat given fertilizer.

In Porto Rico, where the climate is favorable to the blossoming and development of citrus fruit throughout the year, great care should be taken by each grower to determine the effects of fertilization on the time required for the fruit to mature, because of the great change in prices of fruit during the year. Where early or late or out-of-season fruit is produced much higher prices are secured than from midseason sales.

CONCLUSIONS.

The theory that fertilizer requirements for a plant may be determined definitely by the chemical analysis of the soil in which it is growing has been abandoned, as the food elements may be present in abundance, but insoluble or too slowly available to the plants for their support. The analyses of the orchard soils where these experiments were conducted are, however, of unusual value, as they show the actual quantity of food elements in the soil which may become available for the trees, and that these elements are present in such small quantities that a thrifty, profitable orchard could not be maintained without the addition of fertilizer.

It would be impossible to give a formula which would provide for the fertilizer needed in all orchards in Porto Rico, although the results of the experiments under consideration point to one which may be recommended for those having like conditions. As the weather conditions in the citrus-growing sections on the north side

of the island are almost uniform, this will include localities where the soil is of a rather compact, red, sandy clay or red, sandy clay loam. Practically all the land in the citrus-growing sections on the north side of the island except the sandy beach land answers this description. For trees of the age of those in the experiment at the time the harvests were recorded a fertilizer formula providing for 3 per cent nitrogen, 12 per cent phosphoric acid, and 12 per cent potash is recommended. This formula is suggested for use until the exact needs in individual localities are determined. For older trees which have passed their maximum annual growth it would probably be economical to decrease the nitrogen content slightly.

The quantity of fertilizer required varies with the age and general conditions surrounding the tree, but the experiments indicate that for trees six to eight years old which are producing good crops 20 pounds per tree should probably be the minimum. Much larger quantities have been applied in Porto Rico with good results.

By following consistent cultural practices much can be done to lower the need for fertilizer. The heavy tropical rains pack the surface soil, which after a few weeks of drought forms a hard stratum in which the roots can not thrive, and those in the lower soil must provide for the trees. The growth of these lower roots is retarded, and in some localities injured, by the poor subsoil drainage. Cultivating thoroughly during the dry seasons and improving the subsoil drainage will increase the volume of available soil for the trees and lessen the injurious effects of unfavorable weather. By the regular planting of leguminous cover crops, of which there are a number well suited to orchard conditions in Porto Rico, the amount of nitrogen in the fertilizer may be materially decreased, the washing of the surface soil checked, and vegetable matter provided.

The fact that at the conclusion of the experiments the tree roots were occupying practically all the area between the tree rows indicates that for trees set at their distance apart the fertilizer should be applied over the entire orchard area, except near the tree trunks, where the feeding roots are few. For trees set at greater distances apart, the fertilizer should be applied from near the trees to well beyond the tips of the branches.

SUMMARY.

The response to fertilization was very prompt and the effect pronounced on both trees and quantity of fruit produced.

In each plat given but two elements the leaves were smaller and lighter in color than in those given a complete fertilizer. This difference in color was not great in the grove at Bayamon, and was most pronounced in other groves during periods of drought. In the

grove at Pueblo Viejo the color was poorest in the plat given no phosphoric acid, and in the grove at Manati, where no nitrogen was given.

The growth in the check plats was so slow and unsatisfactory that all except one were discontinued before the conclusion of the experiments. Where but two elements were given the growth of both trunk and top was much slower than where a complete fertilizer was given.

The appearance and growth of the trees in plats given a complete fertilizer were practically the same except that in a plat given nitrogen in the form of dried blood they were not as thrifty.

The weight of fruit per tree harvested from the check trees was but 27 per cent of that from the trees given a complete fertilizer.

Where records of yields were made, the crop from plats given a complete fertilizer was decidedly greater than where but two elements were applied. In one grove the gain in yield by plats given three elements over those given two was 80 per cent, and in the other 44 per cent.

When but two elements were applied, the plats given no nitrogen gave the poorest yield. The plats given no potash bore more than the plats given no phosphoric acid or those given no nitrogen.

The average weight of the fruit per hundred was heavier in the plats given no nitrogen than in those where phosphoric acid or potash was omitted.

Where potash was applied in the form of muriate, the crop was heavier in one orchard and slightly lighter in the other than where applied in the form of sulphate. These differences are too small to indicate that for the quantity of fruit production one form of potash is superior to the other. No differences were noted between these plats regarding quality, flavor, or color of the fruit.

In the grove at Pueblo Viejo, where the element nitrogen was applied in the form of nitrate of soda, the yield was but 83.7 per cent of that where an equal amount of nitrogen was given in the form of sulphate of ammonia. At Bayamon there was practically no difference resulting from the two treatments.

The yield from the plat given nitrogen in the form of dried blood was but 75 per cent of that where sulphate of ammonia was given.

No marked difference in flavor of fruit was observed resulting from the application of different fertilizers.

Differences in time of ripening of the fruit in fertilized plats, resulting from different fertilizers applied, were not apparent. The fruit ripened earlier in the check plat than in the fertilized plats.

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